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(54) **METHOD AND SYSTEM FOR SESSION BASED DATA MONITORING FOR WIRELESS EDGE CONTENT CACHING NETWORKS**

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H04M 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04W 4/26*** (2013.01); ***H04M 15/58*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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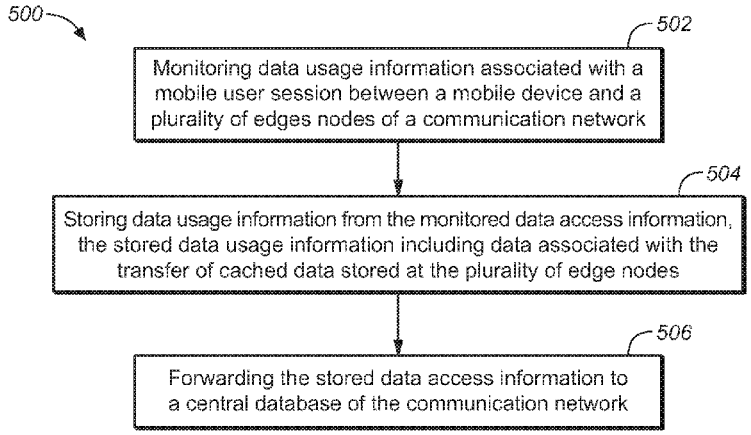
(57) **ABSTRACT**

Aspects of the disclosure pertain to methods and systems that are configured to monitor data usage at a network edge. In an implementation, a method includes monitoring data usage information associated with a mobile user session between a mobile device and a plurality of edges nodes of a communication network, where the plurality of edge nodes includes at least a beginning edge node and a final edge node. The method also includes storing data usage information from the monitored data usage information, the stored data usage information including data associated with the transfer of cached data stored at the plurality of edge nodes. The method further includes forwarding the stored data access information to a central database of the communication network.

20 Claims, 3 Drawing Sheets



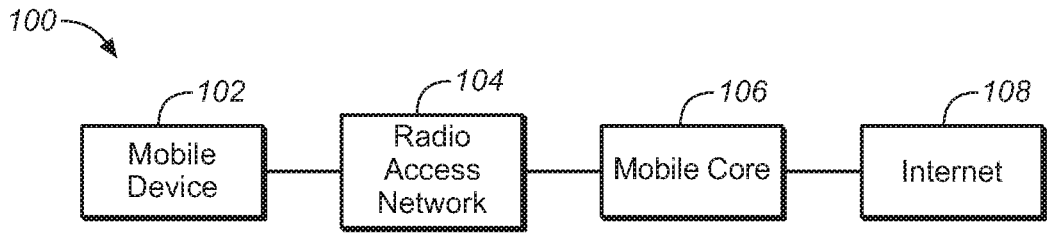


FIG. 1

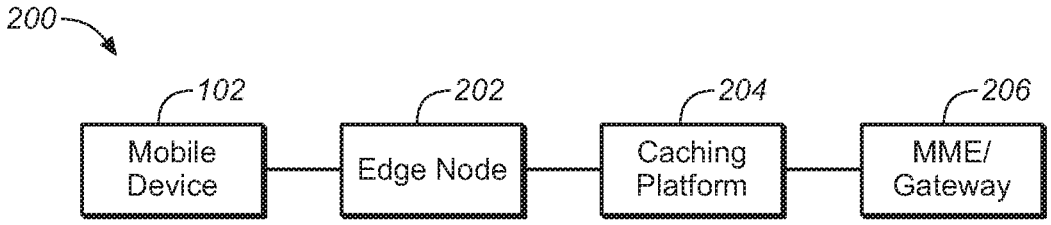


FIG. 2

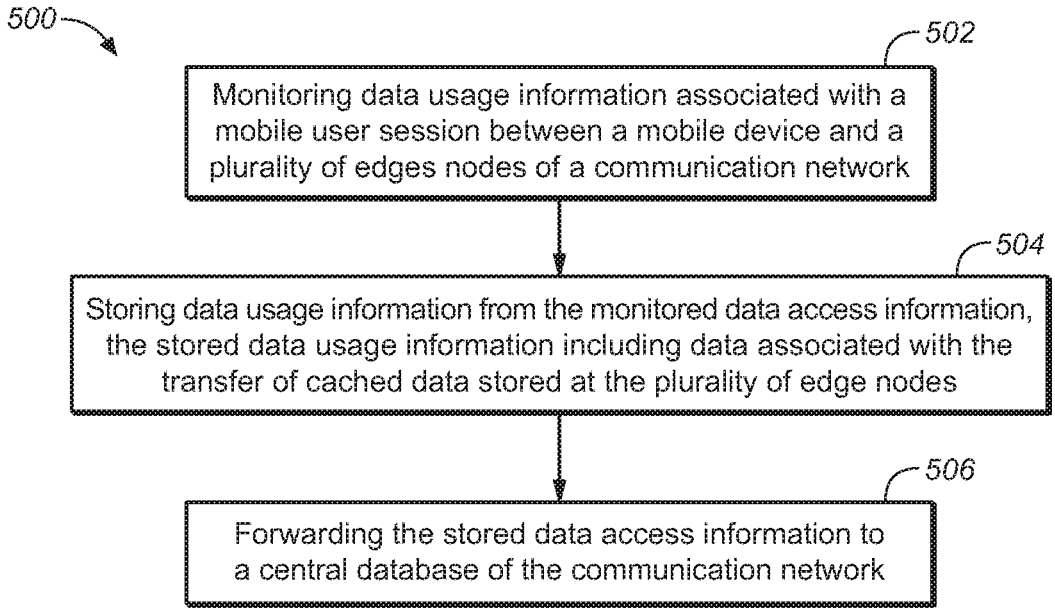


FIG. 5

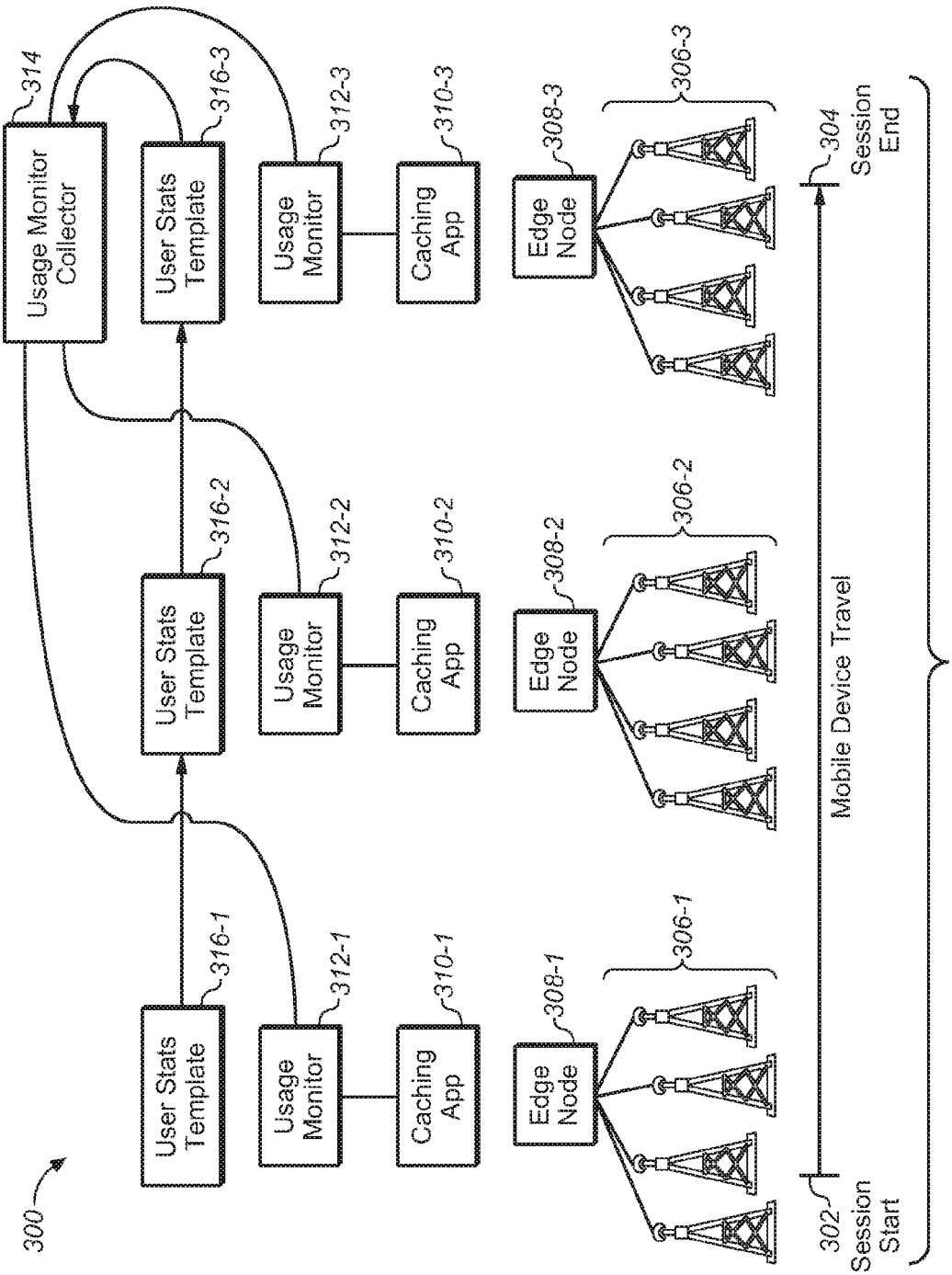

300
Usage Monitor Collector
314
User Stats Template
316-1
316-2
316-3
Usage Monitor
312-1
312-2
312-3
Caching App
310-1
310-2
310-3
Edge Node
308-1
308-2
308-3
306-1
306-2
306-3
302
Session Start
Mobile Device Travel
304
Session End

FIG. 3

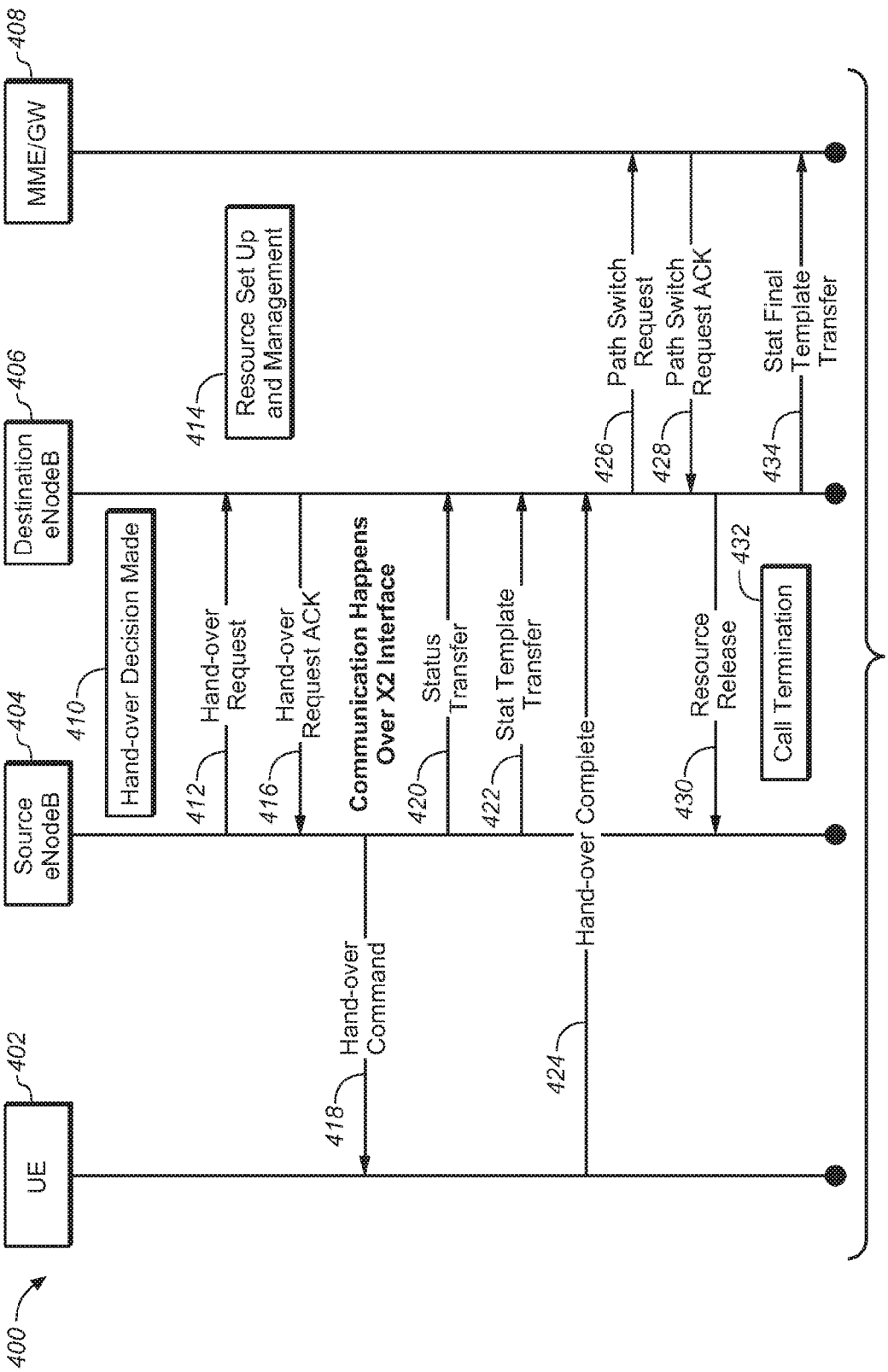

400
UE
402
Source eNodeB
404
Destination eNodeB
406
MME/GW
408
Hand-over Decision Made
410
Hand-over Request
412
Resource Set Up and Management
414
Hand-over Request ACK
416
Communication Happens Over X2 Interface
Hand-over Command
418
Status Transfer
420
Stat Template Transfer
422
Hand-over Complete
424
Path Switch Request
426
Path Switch Request ACK
428
Resource Release
430
Call Termination
432
Stat Final Template Transfer
434

FIG. 4

METHOD AND SYSTEM FOR SESSION BASED DATA MONITORING FOR WIRELESS EDGE CONTENT CACHING NETWORKS

FIELD OF THE INVENTION

The present disclosure relates to the field of network systems and particularly to session based billing on edge content caching networks.

BACKGROUND

In networks, resources and information are shared by computers and user terminals which are interconnected by communication channels. One of the resources that is shared over networks (e.g., mobile networks) is data content, such as audio content (e.g., digital audio files) and video content (e.g., mobile video, over-the-top video). The access of data shared over a network is tracked, particularly by networks that limit access to data by individuals using the network.

SUMMARY

Aspects of the disclosure pertain to methods and systems that are configured to monitor data usage at a network edge. In an implementation, a method includes monitoring data usage information associated with a mobile user session between a mobile device and a plurality of edges nodes of a communication network, where the plurality of edge nodes includes at least a beginning edge node and a final edge node. The method also includes storing data usage information from the monitored data usage information, the stored data usage information including data associated with the transfer of cached data stored at the plurality of edge nodes. The method further includes forwarding the stored data access information to a central database of the communication network.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key and/or essential features of the claimed subject matter. Also, this Summary is not intended to limit the scope of the claimed subject matter in any manner.

BRIEF DESCRIPTION OF THE FIGURES

The Written Description is described with reference to the accompanying figures. The use of the same reference numbers in different instances in the description and the figures may indicate similar or identical items.

FIG. **1** is a block diagram of a communication network in accordance with an example implementation of the present disclosure.

FIG. **2** is a block diagram of a communication network having an edge node in accordance with an example implementation of the present disclosure.

FIG. **3** is a schematic diagram of a communication network providing content to a mobile device that is traveling between communication towers in accordance with an example implementation of the present disclosure.

FIG. **4** is a schematic diagram of a communication network transferring collected data in accordance with an example implementation of the present disclosure.

FIG. **5** is a flow chart illustrating a method for monitoring data usage at a network edge in accordance with an example implementation of the present disclosure.

WRITTEN DESCRIPTION

Embodiments of the invention will become apparent with reference to the accompanying drawings, which form a part

hereof, and which show, by way of illustration, example features. The features can, however, be embodied in many different forms and should not be construed as limited to the combinations set forth herein; rather, these combinations are provided so that this disclosure will be thorough and complete, and will fully convey the scope. Among other things, the features of the disclosure can be facilitated by methods, devices, and/or embodied in articles of commerce. The following detailed description is, therefore, not to be taken in a limiting sense.

Referring to FIG. **1**, a block diagram of a communication network **100** is shown in accordance with an example embodiment of the present disclosure. As shown, the communication network **100** includes a mobile device **102** (e.g., mobile phone, tablet, laptop, or other mobile computing device), a radio access network **104**, a mobile core **106**, and the Internet **108**. In embodiments, the communication network **100** is a collection of computers and other hardware interconnected by communication channels that allow sharing of resources and information (e.g., video files, mobile video, audio files). In embodiments, the communication network **100** is a wireless network (e.g., mobile network). As shown, the mobile device **102** is communicatively coupled to the radio access network **104**, which is communicatively coupled to the mobile core **106**, which is communicatively coupled to the Internet **108**. In embodiments, the mobile device **102** is configured for accessing a service (e.g., providing data content to the mobile device **102**) made available by a server or database provided in the communication network **100**. While the communication network **100** is shown with connectivity to the Internet **108**, it is contemplated that the communication network **100** operates via any suitable communication protocol and with any suitable data content storage/communication system, including but not necessarily limited to: a wide-area cellular telephone network, such as a **3**G cellular network, a **4**G cellular network (including a long term evolution (LTE) standard), or a global system for mobile communications (GSM) network; a wireless computer communications network, such as a WiFi network (e.g., a wireless local area network (WLAN) operated using IEEE 802.11 network standards); an internet; the Internet; a wide area network (WAN); a local area network (LAN); a personal area network (PAN) (e.g., a wireless personal area network (WPAN) operated using IEEE 802.15 network standards); a public telephone network; an extranet; an intranet; and so on. However, this list is provided by way of example only and is not meant to be restrictive of the present disclosure. Further, the mobile device **102** can be configured to communicate with a single network or multiple networks across different access points.

In embodiments, the Radio Access Network **104** provides a communicative coupling between the mobile device **102** and the mobile core **106** (or core network). In embodiments, the Radio Access Network **104** includes one or more edge nodes configured for sending, receiving, and forwarding information between the mobile device **102** and the mobile core **106**. In embodiments, the Radio Access Network **104** stores frequently accessed data in a cache storage such that the mobile device **102** accesses the cached data directly from the Radio Access Network rather through the mobile core **106** (which can also include cached data) or the Internet **108**. By caching frequently accessed data content closer to the end user (e.g., closer to the mobile device **102**), such as at the mobile core level or at the radio access network level, the data content can be served by local cached content to be accessed more rapidly by the end user than when accessed through the Internet **108** via the mobile core **106**. By monitoring data

usage at the mobile core level, the communication network **100** can overlook cached data content supplied from an edge node of the radio access network **104**, resulting in incomplete records of data access.

In embodiments, such as the embodiment shown in FIG. **2**, a communication network **200** is configured to monitor data usage, including cached data, at the edge node level or radio access network level. As shown, communication network **200** includes the mobile device **102**, an edge node **202**, a caching platform **204**, and a mobile management entity (MME)/gateway (GW) **206**. The caching platform **204** is communicatively coupled between the edge node **202** and the MME/gateway **206** and is configured to store frequently accessed data at the edge node **202** for subsequent access by the mobile device **102**. In embodiments, the caching platform **204** is co-located with the edge node **202**. In embodiments, the edge node **202** is dependent on the communication protocol of the communication network **200**. For example, in embodiments the edge node **202** is an eNodeB (e.g., E-UTRAN Node B, Evolved Node B) or a Radio Network Controller (RNC). In embodiments, the caching platform **204** is a component that transparently stores data (e.g., objects, object data) so that future requests for that data can be served faster, where in embodiments, the caching platform **204** is co-located with eNodeB or RNC. In embodiments, the caching platform **204** is used for temporary storage of data likely to be used again. Caching is valuable in that it reduces network bandwidth and improves the quality of experience for subscribers. In embodiments, data usage is monitored at the edge node **202** in order to account for access of data cached by the caching platform **204**. For example, in embodiments, a flow level monitoring module (e.g., NetFlow, NetStream, IPFIX, and the like) is utilized to monitor the access of data at the edge node **202**, and in particular, monitors the access of data cached by the caching platform **204**. As will described with reference to FIG. **3**, in embodiments, the usage data collected at each edge node of a communication network is reported directly to a central statistic collector, or a compilation of data is reported to the central statistic collector at the completion of a communication session of a mobile device.

Referring now to FIG. **3**, a schematic diagram of a communication network **300** providing content to a mobile device that is traveling between communication towers is shown in accordance with an example implementation of the present disclosure. As shown, a mobile device (such as mobile device **102**) begins a communication session with communication network **300** at session start **302** and proceeds in a direction of travel to the session end **304** location. During travel from the session start **302** to the session end, the mobile device encounters a number of communication towers **306** (shown as **306-1**, **306-2**, and **306-3**), which in embodiments are cellular communication towers. In embodiments, the mobile device begins a session at one tower (such as **306-1**) and is transferred to another tower (such as one or more of **306-2** and **306-3**) when the mobile device is positioned within range of the subsequent tower during travel. Each communication tower **306** is communicatively coupled to one or more edge nodes **308** (shown as **308-1**, **308-2**, and **308-3**), where communication towers **306-1** are communicatively coupled to edge nodes **308-1**, communication towers **306-2** are communicatively coupled to edge nodes **308-2**, and communication towers **306-3** are communicatively coupled to edge nodes **308-3**. As such, the user's session can be served by multiple edge nodes **308** prior to termination of the session at the completion of the call. A session begins at session start **302** when the mobile device requests data content from the cache in the edge node **308-1**. As described, certain data content can be cached at an edge node, such that a caching application **310** (shown as **310-1**, **310-2**, and **310-3**) is configured to manage cached data content for the edge nodes **308**. The communication network **300** includes a usage monitor **312** (shown as **312-1**, **312-2**, and **312-3**) configured to monitor the data usage of the mobile device at the edge nodes. As shown, the usage monitor **312-1** is communicatively coupled to caching application **310-1** and is configured to monitor the data usage of the mobile device from edge nodes **308-1** as the mobile device communicates with communication towers **306-1**. The usage monitor **312-2** is communicatively coupled to caching application **310-2** and is configured to monitor the data usage of the mobile device from edge nodes **308-2** as the mobile device communicates with communication towers **306-2**. The usage monitor **312-3** is communicatively coupled to caching application **310-3** and is configured to monitor the data usage of the mobile device from edge nodes **308-3** as the mobile device communicates with communication towers **306-3**. In embodiments, the usage monitor **312** and the caching application **310** are modules loaded in the edge node **308** platform.

When the session begins at session start **302**, the usage monitor **312-1** begins collecting usage data associated with edge nodes **308-1**. In embodiments, the collected usage data is sent from the usage monitor **312** to a usage monitor collector **314**. In embodiments, the usage monitor collector **314** is incorporated in the mobile core level, such as in the MME or a packet data network (PDN) gateway. The MME is configured to manage and store user equipment (UE) (e.g., mobile devices) contextual data, including, but not limited to, UE identity, UE mobility state, user security parameters, and the like). The PDN gateway is configured to perform policy enforcement, packet filtering for each user, charging support, lawful interception, packet screening, and the like. The PDN gateway is configured provide connectivity between the UE and external packet data networks by functioning as a point of exit and entry of traffic for the UE. In embodiments, the UE has connectivity with more than one PDN gateway for accessing multiple PDNs. In embodiments, the usage monitor **312** tracks data usage associated with data cached at the edge node **308** (or other nodes closer to the user than the mobile core **106**) and stores the information in a user statistics template **316** (shown as **316-1**, **316-2**, and **316-3**) as a table entry in a data table implemented in hardware and/or software.

In embodiments, when the mobile device moves to a different communication tower **306** (e.g., from communication towers **306-1** to communication towers **306-2**), the user data collected by the usage monitor **312** and stored in the user stats template **316** is transferred to the next usage monitor **312** (e.g., the data collected by the usage monitor **312-1** is transferred to the usage monitor **312-2** to be stored in the user stats template **316-2**). In embodiments, if the session continues while the mobile device moves to another communication tower **306** (e.g., from communication towers **306-2** to communication towers **306-3**), the cumulative data collected from the usage monitors **312** (e.g., the data collected by the usage monitor **312-1** and by the usage monitor **312-2** and stored in the user stats template **316-2**) is transferred to the usage monitor **312** associated with the edge nodes **308** of the subsequent communication tower **306** (e.g., usage monitor **312-3**). When a user finishes his/her communication session, the user statistics template is forwarded to the usage monitoring collector **314**. In other words, all the user data usages during the entire communication session (from **302** to **304**) will get forwarded to the collector **314**. This can avoid any duplicated counts that may occur during the communication session, and can monitor data service provided by all edge nodes. In

embodiments, the transfer of information between the communication towers **306** is carried out via a communication platform or interconnect interface, including but not limited to, a System Architecture Evolution (SAE) platform, the X2 interface, and the like.

In embodiments, the usage monitor **312** tracks usage data pertinent to the session and stores the data in the user stats template **316**, where the data includes, but is not limited to, user identification; application type; amount of data (e.g., bytes) served from local cache (such as the edge node **308** cache, served by the caching app **310**); security credentials; quality of service (QoS) parameters; data quality (e.g., high, medium, low, such as for streamed video content); whether retries were attempted (e.g., indicating poor radio interface); amount or portion of a particular data content viewed (e.g., was a video data content viewed completely, partially, from the beginning, from the middle, towards the end, etc.); and the like. In embodiments, the tracked data is maintained for each user of the communication system **300**, such as in a tabular format.

Referring now to FIG. **4**, a schematic diagram of a communication network **400** configured to transfer collected data is shown in accordance with an example implementation of the present disclosure. As shown, the communication network **400** includes user equipment (UE) **402**, a source eNodeB **404**, a destination eNodeB **406**, and a mobile management entity (MME)/gateway (GW) **408**. The UE **402** begins a session by accessing data from the source eNodeB **404**. When the UE travels between communication towers (e.g., as described with reference to FIG. **3**), a transfer of data occurs between the source eNodeB **404** and the destination eNodeB **406** as part of the communication hand-over. As shown, a hand-over decision is made **410** when the UE **402** transfers to range of a communication tower, such as a communication tower independent of the source eNodeB **404**. Once the hand-over decision is made **410**, a hand-over request **412** is sent from the source eNodeB **404** to the destination eNodeB **406**. A resource set up and management is initiated at **414**. In embodiments, the resource set up and management includes applications/protocols to manage the transfer of the session of the UE **402** and is performed by a mobile core, such as by the MME/GW **408**. The destination eNodeB **406** provides an acknowledgment of the handover request at **416** to the source eNodeB **404**. The source eNodeB **404** initiates a hand-over command at **418** to the UE **402**. At **420**, the source eNodeB **404** begins a status transfer to the destination eNodeB **406**. At **422**, the source eNodeB **404** begins a stat template transfer (e.g., as described with reference to FIG. **3**). At **424**, the UE **400** completes the hand-over. At **426**, the destination eNodeB **406** initiates a path switch request to the MME/GW **408**, and at **428** the MME/GW **408** returns a path switch request acknowledgment to the destination eNodeB **406**. At **430**, the destination eNodeB **406** initiates a resource release to the source eNodeB **404**. At **432**, the call of the UE terminates, upon which the destination eNodeB **406** initiates a stat final template transfer to the MME/GW **408** at **434**. In embodiments, the stat final template transfer at **434** includes the cumulative data monitored during the call of the UE **402** (e.g., data tracked by usage monitor **312** and stored in user stats template **314**).

Referring now to FIG. **5**, a flow chart illustrating a method **500** for monitoring data usage at a network edge is shown in accordance with an example implementation of the present disclosure. Method **500** includes a step of monitoring data usage information associated with a mobile user session between a mobile device and a plurality of edges nodes of a communication network (Step **502**). In embodiments, the plurality of edge nodes includes at least a beginning edge node and a final edge node. For example, in embodiments the usage monitor **312** monitors data access associated with a mobile session between a mobile device (e.g., mobile device **102**, UE **402**, etc.) and the edge node (e.g., edge node **202**, edge node **308**, etc.).

Method **500** further includes a step of storing data usage information from the monitored data usage information, where the stored data usage information includes data associated with the transfer of cached data stored at the plurality of edge nodes (Step **504**). For example, in embodiments the stored data access information includes information associated with the transfer of data cached by the caching platform **204** from the edge node (e.g., edge node **202**, edge node **308**, etc.) to the mobile device (e.g., mobile device **102**, UE **402**, etc.).

Method **500** further includes a step of forwarding the stored access information to a central database of the communication network (Step **506**). For example, in embodiments the usage monitor **312** forwards the stored access information to the usage monitor collector **314** (e.g., MME, GW, etc.).

It is to be noted that the foregoing described embodiments may be conveniently implemented using conventional general purpose digital computers programmed according to the teachings of the present specification, as will be apparent to those skilled in the computer art. Appropriate software coding may readily be prepared by skilled programmers based on the teachings of the present disclosure, as will be apparent to those skilled in the software art.

It is to be understood that the embodiments described herein may be conveniently implemented in forms of a software package. Such a software package may be a computer program product which employs a non-transitory computer-readable storage medium including stored computer code which is used to program a computer to perform the disclosed functions and processes disclosed herein. The computer-readable medium may include, but is not limited to, any type of conventional floppy disk, optical disk, CD-ROM, magnetic disk, hard disk drive, magneto-optical disk, ROM, RAM, EPROM, EEPROM, magnetic or optical card, or any other suitable media for storing electronic instructions.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A method for monitoring data usage at a network edge comprising:

monitoring data usage information associated with a mobile user session between a mobile device and a plurality of edges nodes of a communication network, the plurality of edge nodes including at least a beginning edge node and a final edge node, the data usage information associated with the mobile user session including data usage information associated with cached data stored at an edge node of the plurality of edge nodes;

storing data usage information from the monitored data usage information, the stored data usage information including data associated with the transfer of cached data stored at the plurality of edge nodes; and

forwarding the stored data usage information to a central database of the communication network.

2. The method as recited in claim 1, further comprising:

transferring from the beginning edge node to the final edge node, the stored data access information associated with the transfer of cached data stored at the beginning edge node to the mobile device prior to forwarding the stored data usage information to the central database of the communication network.

3. The method as recited in claim 1, wherein the communication network includes one or more intermediate nodes associated with the transfer of cached data to the mobile device during the mobile user session.

4. The method as recited in claim 3, wherein the one or more intermediate edge nodes facilitate transfer of data to the mobile device during the mobile user session after the beginning edge node and prior to the final edge node.

5. The method of claim 3, further comprising:

monitoring data usage information associated with the mobile user session between the mobile device and each edge node of the communication network; and

storing the monitored data usage information associated with the mobile user session between the mobile device and each edge node of the communication network.

6. The method as recited in claim 5, further comprising:

transferring the stored data access information associated with the transfer of cached data stored at one of the one or more intermediate edge nodes to a subsequent intermediate edge node or the final edge node prior to forwarding the stored data usage information to the central database of the communication network.

7. The method of claim 6, further comprising:

storing the data usage information associated with cached data stored at an edge node of the plurality of edge nodes in a user statistics template; and

forwarding the stored data usage information from each edge node of the communication network to the central database of the communication network upon termination of the mobile user session.

8. A non-transitory computer-readable medium having computer-executable instructions for performing a method for monitoring data usage at a network edge, the method comprising:

monitoring data usage information associated with a mobile user session between a mobile device and a plurality of edges nodes of a communication network, the plurality of edge nodes including at least a beginning edge node and a final edge node, the data usage information associated with the mobile user session including data usage information associated with cached data stored at an edge node of the plurality of edge nodes;

storing data usage information from the monitored data usage information, the stored data usage information including data associated with the transfer of cached data stored at the plurality of edge nodes; and

forwarding the stored data usage information to a central database of the communication network.

9. The non-transitory computer-readable medium as recited in claim 8, the method further comprising:

transferring from the beginning edge node to the final edge node, the stored data access information associated with the transfer of cached data stored at the edges node to the mobile device prior to forwarding the stored data usage information to the central database of the communication network.

10. The non-transitory computer-readable medium as recited in claim 8, wherein the communication network includes one or more intermediate edge nodes associated with the transfer of cached data to the mobile device during the mobile user session.

11. The non-transitory computer-readable medium as recited in claim 10, the method further comprising:

monitoring data usage information associated with the mobile user session between the mobile device and each edge node of the communication network; and

storing the monitored data usage information associated with the mobile user session between the mobile device and each edge node of the communication network.

12. The non-transitory computer-readable medium as recited in claim 11, the method further comprising:

transferring the stored data access information associated with the transfer of cached data stored at one of the one or more intermediate nodes to a subsequent intermediate node or the final edge node prior to forwarding the stored data usage information to the central database of the communication network.

13. The non-transitory computer-readable medium as recited in claim 12, the method further comprising:

storing the data usage information associated with cached data stored at an edge node of the plurality of edge nodes in a user statistics template; and

forwarding the stored data usage information from each end node of the communication network to the central database of the communication network upon termination of the mobile user session.

14. A system for monitoring data usage at a network edge, the system comprising:

a processor;

a memory communicatively coupled to the processor, the memory having computer executable instructions stored thereon, the computer executable instructions configured for execution by the processor to:

monitor data usage information associated with a mobile user session between a mobile device and a plurality of edges nodes of a communication network, the plurality of edge nodes including at least a beginning edge node and a final edge node, the data usage information associated with the mobile user session including data usage information associated with cached data stored at an edge node of the plurality of edge nodes;

store data usage information from the monitored data usage information, the stored data usage information including data associated with the transfer of cached data stored at the plurality of edge nodes; and

forward the stored data usage information to a central database of the communication network.

15. The system as recited in claim 14, wherein the computer executable instructions are configured for execution by the processor to transfer, from the beginning edge node to the final edge node via intermediate edge nodes, the stored data access information associated with the transfer of cached data stored at the beginning edge node to the mobile device prior to forwarding the stored data usage information to the central database of the communication network.

16. The system as recited in claim 14, wherein the communication network includes one or more intermediate nodes associated with the transfer of cached data to the mobile device during the mobile user session.

17. The system as recited in claim 16, wherein the one or more intermediate edge nodes facilitate transfer of data to the mobile device during the mobile user session after the beginning edge node and prior to the final edge node.

18. The system as recited in claim **16**, wherein the computer executable instructions are configured for execution by the processor to:

monitor data usage information associated with the mobile user session between the mobile device and each end node of the communication network; and

store the monitored data usage information associated with the mobile user session between the mobile device and each end node of the communication network.

19. The system as recited in claim **18**, wherein the computer executable instructions are configured for execution by the processor to transfer the stored data access information associated with the transfer of cached data stored at one of the one or more intermediate nodes to a subsequent intermediate node or the final edge node prior to forwarding the stored data usage information to the central database of the communication network.

20. The system as recited in claim **19**, wherein the computer executable instructions are configured for execution by the processor to:

store the data usage information associated with cached data stored at an edge node of the plurality of edge nodes in a user statistics template; and

forward the stored data usage information from each end node of the communication network to the central database of the communication network upon termination of the mobile user session.

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